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Description

[Insert title of invention]On-cue hot-water circulator

BACKGROUND OF INVENTION

[0001] This invention relates to a hot-water circulator, and more specifically to a hot-water circulator that provides on-cue hot water and serves as a water-conservation device.

[0002] 1. Background

[0003] A common problem with potable water systems which have an associated water heater is that once the tap, valve or faucet controlling the flow of the water from the heater is turned off, the water which is left in the line between the valve and the heater container gradually cools over time making a user wait until the cooled water within the line is purged from the line and through the drain and the line is once again filled with warm water. This causes wa-ter and energy to be wasted as it can require up to several minutes for the line to be purged and again filled with warm water.

[0004] This problem can be particularly troublesome for large, single story homes, which tend to be more spread out than multilevel homes, where the water heater can be great distances from the farthest hot water tap.

[0005] There are several known proposed solutions to this problem but they each have their own problems and issues. The first one is called Hot-Water Re-Circulation, which is also referred to as hot-water circulation. This method of conserving water wasted when purging cold water from the hot water plumbing system works well, but it is very expensive to operate. It consists of a closed loop in the hot-water plumbing system, looping through the water heater, with the introduction of a circulation pump located next to the water heater, with its intake connected to the hot-water return line and its output connected to a water pipe that returns the re-circulated, cooler hot water directly into the bottom of the water heater holding tank to be re-heated.

[0006] This system circulates and "re-circulates"hot water in the hot-water plumbing system, maintaining hot water throughout the system. Each faucet or hot-water appliance will have access to "instant"hot water. Often, as an energy saving addition, a timer is used to provide re-

circulation only during times when hot water use is anticipated.

[0007] The problem with this system is the fact that heating water in the water heater and the hot-water plumbing system is very expensive. The water heater is forced to cycle often to maintain the heat. If the system re-circulates the water and hot water is not used or is seldom used, the energy consumed to keep the water hot is wasted. Even with a timer, constant re-circulation of water through the hot-water system causes the water heater to cycle more often, using large amounts of energy. Also, if the hot water is requested at a time not anticipated, when water is allowed to cool in the hot-water system, the original problem exists; water is wasted purging cooled water from the hot-water system, from the water heater to the point-of-request.

[0008] Another proposed solution is a Hot-Water Circulation system. This is a method of conserving water wasted when purging cold water from the hot water plumbing system which is similar to the system above, except it is used where a closed-loop in the hot-water plumbing system is not available where there is no dedicated hot-water line back to the water heater. This can be considered as a

retrofit to an existing plumbing system, where re-circulation was not considered. This system consists of a circulation pump that is located above the water heater, with its intake coming from the hot water outlet of the water heater, and its output returning hot water into the hot-water system. The pump is designed to allow water to pass through it with little or no restriction, when not operating, and it also has an integrated timer to provide circulation only during periods when hot water usage is anticipated. The key to this system is a manifold valve with fittings to allow its location beneath a sink, or co-located with another suitable fixture, which must have both hot and cold-water outlets, and for being installed between the respective hot and cold water supply valves and their corresponding faucets. One end of the manifold valve has an intake and an outlet for the hot water supply line and is installed between the standard hot-water supply valve and the hot-water faucet using two standard flexible hoses. The other end of the manifold valve has an intake and an outlet for the cold water supply line and is installed between the standard cold-water supply valve and the cold-water faucet, also using two standard flexible hoses. The manifold valve body connects and mixes the hot-water

system with the cold-water system through a temperature-actuated valve that is normally opened. This system is designed for the valve to be co-located with a suitable fixture, located farthest from the water heater.

[0009] With this method, during periods of anticipated use, the circulation pump runs continually. When the circulation pump is operating, water passes from the hot-water system into the cold-water system, for return to the water heater. During this time, the water in the cold-water plumbing system flows in the opposite direction from normal operation, from the plumbing fixture back to the water heater. Because the water in the hot-water system is cold until purged, the manifold with the normally opened, temperature-actuated valve allows the water to pass freely from the hot-water system into the cold-water system. Once the cold water is purged and hot water begins to pass through the temperature-actuated valve, the valve closes and prevents further mixture between the hot and cold-water systems, even though the circulation pump continues to operate. Thus, water is circulated, but not re-circulated. In a "properly"designed plumbing system, all fixtures will now have "instant" hot water. When the water, and the media of the manifold valve, cools to a

preset temperature, the temperature-actuated valve re-opens allowing the water to pass from the hot-water system into the cold-water system again, maintaining hot water throughout the hot-water plumbing system.

[0010] Few thermal-actuated valves are able to immediately register a temperature change (up or down) and close before passage of hot water into the cold-water system. Turning on cold water, at the fixture where the manifold valve is installed, may result in warm-to-hot water being provided from the cold-water system, until that water is purged from the cold-water system. It is assumed that this condition will be acceptable at that fixture.

[0011] If this system really worked as well as the idea wished, it would only have the same problems as the re-circulation system described above, i.e.: if the water is not used during periods of anticipated use, the energy used to heat the water is wasted, or if hot water is desired during periods when use is not anticipated, purged water is wasted (original problem). However, there are a few other problems: a) Use of cold water, during a non-circulating period, at the fixture where the manifold valve is installed, or from an adjacent cold-water fixture, such as a toilet, will draw water from the hot-water system through the

manifold valve (which is always opened when cold), causing the water heater to cycle needlessly. b) The temperature-actuated valve may allow an indeterminate amount of warm-to-hot water to pass into the cold-water system at the fixture where the temperature-actuated valve is installed. A request for "cold" water at that fixture may result in water being wasted down the drain, waiting for the hot water to be purged from the cold-water system. c) The temperature-actuated valve will retain heat much better than the water throughout the rest of the hot water system, resulting in the valve remaining closed after the water in the hot-water system has cooled below an acceptable temperature. As such, when hot water is desired, it will not be available, without manually purging the system with water down the drain, even if the circulation pump is operating. At best, this system can only provide part-time "instant" hot water during periods when hot water use is anticipated and this with no reliability for when the water will actually be hot.

[0012] Another method is the On-demand hot-water circulator. This method of conserving water wasted when purging cold water from the hot-water system consists of an electronic control module, a thermal sensor, a normally closed

solenoid valve, a momentary-on actuation switch or button (wired or wireless), and a high-performance pump (not a typical low-speed circulation pump), all constructed in modular fashion for installation beneath a sink, or it may be similarly co-located with another suitable plumbing fixture, which has both hot and cold-water fixtures. Installation also requires the replacement of the hot and cold-water supply valves for the plumbing fixture, with proprietary "T-fittings,"wherever the device is installed. The device is meant to be installed at the plumbing fixture farthest from the water heater. This device has an inlet, which is connected to an outlet provided on the newly installed hot-water supply valve, or "T-fitting,"and an outlet, which is connected to an inlet provided on the newly installed cold-water supply valve, or "T-fitting." This installation connects and mixes the hot-water system with the cold-water system, which are separated by the electrically actuated, normally closed, solenoid valve.

[0013] When hot water is desired, a counter-top or wall-mounted button is depressed, sending a signal to the control module. As long as the thermal sensor detects cold temperature water, as measured in the device, the solenoid valve opens and the high-performance pump begins circulating

the water through the device, purging cooled water from the hot-water system into the cold-water system, and back to the water heater in reverse-flow fashion. When the control module detects a preset temperature, as signaled from the thermal sensor, the pump stops and the solenoid valve closes, preventing further mixture of water between the hot and cold-water systems. In a "properly" designed plumbing system, all fixtures will now have hot water. Because the pump is high-performance, and because the water does not pass through any water-restriction valves or outlets (often found in faucets and shower heads), hot water is delivered to the point-of-demand much more quickly than if the water was allowed to run out of the faucet at full volume.

[0014] Few thermal sensors are able to immediately register a temperature change, therefore turning on cold water at the fixture where the device is installed, immediately after a demand for hot water, may result in warm-to-hot water being provided from the cold-water system, until that water is purged from the system. It is assumed that this condition will be acceptable, because hot water was originally desired.

[0015] The problem with this method is the difficulty of installa-

tion. Because few sinks in bathrooms (if any) have 110-volt access available beneath them, the services of a licensed electrician (most areas) will be required to complete the installation. Use of an extension cord could present safety and cosmetic concerns. The required replacement of the hot and cold-water supply valves with the required proprietary "T-fittings" necessitates shutting off the water for the complete system, both hot and cold-water. Further, most consumers would have to employ the services and skill of a plumber to use an open flame torch to sweat the old valves off and sweat the new valves on, and then test for leaks. There is never enough space under a sink, even less with this device installed. The noise the system would make, even though relatively quiet, could be an annoyance, especially if installed adjacent to a bedroom. The button required for operating the system poses another problem. A button would have to be placed near each point-of-demand. Wireless buttons are available, but these could be considered unsightly (cosmetic detraction), and would require batteries from time-to-time (low-level annoyance). A casual user may not know to push the button for hot water, without signage (another cosmetic detraction), so guests in the facility

where the system is installed my not take advantage of it.

[0016] There are two problems anticipated with operation of this method: a) the thermal sensor will retain heat longer than the water throughout the hot-water system, which will create instances when the consumer "demands" hot water, but the system will not operate to provide it. During these instances, the consumer must manually purge the system by allowing the cooled water from the hot-water system to pour down the drain (original problem). b) If the water heater fails, providing cold water in both systems (hot and cold), the circulation may continue for an extended period of time before the system shuts itself down. With wireless actuation buttons, it is possible that a water heater failure could occur when no one is present (work-day or holi-days) and a stray RF signal (garage door opener for exam-ple) could initiate a false demand.

[0017] 2. Prior Art

[0018] United States Patent 6,164,307 by Byles and issued on December 26, 2000 is for a non-circulating, rapid, hot tap water apparatus and method. It discloses a plumbing sys-tem having a warm water outlet for rapidly delivering hot water through the plumbing system to the warm water outlet and is comprised of a diverter valve attachable to a

building water pipe upstream of the warm water outlet for purging cold water from the water pipe, a diverter pipe section extending from the diverter valve, a back flow preventer in flow relationship with the diverter pipe section, and a flow control regulator in flow relationship with the diverter pipe section, whereby a small controlled flow of cold water may be diverted from the water pipe to thereby cause rapid delivery of warm water to the warm water outlet when actuated.

[0019] United States Patent 5,603,344 by Hall, Jr. and issued on February 18, 1997 is for an apparatus for recovering and saving chilled water in hot water lines having adjustable thermostatic control. It discloses a water saving device for use with domestic hot water systems of the noncirculating storage tank heater type and uses a hydraulic motor to drive a water pump, to pump water from the hot water pipe to a cold water pipe.

[0020] United States Patent 5,323,803 by Blumenauer and issued on June 28, 1994 is for an instant hot water device. It discloses an instantaneous hot water device comprised of a gate valve means connected to a hot water line and having a gate valve and a gate valve seat providing a controlled flow of hot water from the hot water line into a ball valve

means having a ball check and a first ball valve seat having slot cooperating with the ball check to provide a small, controlled flow of hot water into a cold water line and a second ball valve seat cooperating with the ball check to prevent flow of cold water into the gate valve means and the hot water line.

[0021] United States Patent 5,277,219 by Lund and issued on January 11, 1994 is for a hot water demand system suitable for retrofit. A control system causes the pump to circulate water from the hot water line into the cold water line and back to the hot water source when a hot water valve on said plumbing fixture is turned on. A temperature sensor stops the pump, via the control system, to prevent heated water from being circulated through the cold water delivery lines.

[0022] United States Patent 5,183,029 by Ranger and issued on February 2, 1993 discloses a supply system including at least one user terminal such as a shower head to which blended hot and cold water are supplied at a selected temperature, the cold water of the blend is supplied via a check valve which responds to changes in hydrodynamic pressure so as to regulate the volumetric flow of cold water and thereby compensate for changes of water demand

in other parts of the system.

[0023] United States Patent 5,105,846 by Britt and issued on April 21, 1992 discloses a purge line to return cooled water in a hot water line directly to a cold water line to avoid wasting water by draining the cooled water while awaiting arrival of hot water at a hot water outlet valve. The purge line is connected in near adjacency to a hot water outlet valve to minimize the amount of cooled water still in the hot water line between the purge line and the valve.

[0024] United States Patent 5,009,572 by Imhoff, et al. and issued on April 23, 1991 discloses a compact and self-contained circular water conservation device having a source of pressurized water, a hot water supply line, a cold water supply line, a hot water heater, and outlet fixtures coupled to the hot and cold water supply lines. The water conservation device includes essentially an electric water pump for pumping water from the hot water supply line into a solenoid valve.

[0025] United States Patent 4,945,942 by Lund and issued on August 7, 1990 is for an accelerated hot water delivery system. It discloses a plumbing system for accelerated hot water delivery to a plurality of plumbing fixtures from a hot water source. Flow switch means are provided to en-

able a pump to circulate hot water to the plumbing fixtures in response to water being withdrawn from a plumbing fixture. In addition, the hot water source may include a hot water recovery apparatus for withdrawing hot water from circulation pipes subsequent to cessation of water flow from a plumbing fixture.

[0026] United States Patent 4,750,472 by Fazekas and issued on June 14, 1988 discloses a control means and process for a recirculating hot water system having a hot water supply pipe and a hot water return pipe connected in a loop between a hot water outlet of a hot water tank and a return inlet to that tank, and having an electrically controlled recirculating pump in the loop, for keeping sufficient circulation in the loop as to assure substantially instant dispensing of water of a desirably high temperature.

[0027] United States Patent 4,201,518 by Stevenson and issued on May 6, 1980 discloses a recirculating hot water system includes a hot water supply pipe and a hot water return pipe connected in a loop between a hot water outlet of a hot water tank and a return inlet to that tank. An electrically controlled recirculating pump is placed in the return pipe between the inlet to the hot water tank and the supply pipe, which has hot water taps located at various

points along it.

[0028] There is still room for improvement in the art.

Summary of Invention

[0029] The present invention relates to a water-conservation device which saves potable water that is most often allowed to pour out of the hot-water faucet of a sink, tub, or shower, or out of the valve of a washing machine, dishwasher, or other hot-water-using appliance, to be wasted down the drain, while waiting for the desired hot water to arrive from the water heater.

[0030] The current invention is an on-cue hot-water circulator. This device and method consists of an electronic control module, a manifold containing a check valve and/or a normally closed solenoid valve, a flow switch, and a high-performance pump (not a typical circulation pump), that is also designed or selected for its ability to allow water to pass through it with little or no restriction, when not operating.

[0031] The object of this invention is to provide a way to conserve water and energy that is easy to operate and automatic in its use, and that can be easily installed by most do-it-yourselfers, with no need to interrupt a complete

water system.

Brief Description of Drawings

[0032] Without restricting the full scope of this invention, the preferred form of this invention is illustrated in the following drawings:

[0033] FIG 1 shows the basic components of the invention;

[0034] FIG 2 shows the system in operation;

[0035] FIG 3 shows a flow chart of how the system works;

[0036] FIG 4 displays a Retrofit connection; and

[0037] FIG. 5 shows the retrofit hook up.

Detailed Description

[0038] The following description is demonstrative in nature and is not intended to limit the scope of the invention or its application of uses.

[0039] There are a number of significant design features and improvements incorporated within the invention.

[0040] The current invention is an on-cue hot-water circulator. As shown in Figure 1, this device 1 and method consists of an electronic control module 10, a manifold 20 containing a check valve 25, and/or a normally closed solenoid valve 30, a flow switch 40, and a high-

performance pump 50 (not a typical circulation pump), that is also designed or selected for its ability to allow water to pass through it with little or no restriction, when not operating.

[0041] In the current invention there is no temperature-sensing device. This distinguishes it from other devices and methods. There are two separate installation types, depending on whether the plumbing system is "on-cue-ready,"or if the plumbing system requires a retrofit installation, where no hot-water return line is available.

[0042] In the preferred embodiment all components of the device are located on or within close vicinity of the water heater 60. A high-performance pump 50 is mounted above the water heater 60 with its outlet connected to the inlet (cold-water supply) of the water heater. The flow switch 40 is connected to the inlet of the pump 50 and the water supply is connected to the flow switch. The outlet of the hot-water system return line 220 connects to the inlet end of the manifold 20. The manifold 20 outlet connects to the inlet of a standard T-fitting 70 in the water supply line 80, which supplies system water from one direction and provides water to the water heater 60 in the other direction, which has an outlet connected to the inlet of the

flow switch 40. The control module 10 mounts on a wall 90 near the water heater 60, and is attached to a power source, which in the preferred embodiment is provided by a 110-volt standard grounded outlet through a 110-volt service cord with a standard 3-prong, grounded plug. The high performance pump 50 plugs into a switched receptacle provided on the control module 10. The flow switch 40 operates on low-voltage and is attached to terminals provided on the control module 10. The solenoid valve 30 in the manifold 20 is also low voltage and connects to the control module through a 1 pair, appropriate gage wire, which attaches to the manifold 20 and to the control module 10 by terminals provided.

[0043] The control module 10 operation is the same for both the standard and retrofit installations. In the preferred embodiment, besides the 110 volt switched plug, low-voltage flow switch terminals, and low-voltage solenoid terminals already mentioned, it also has two flush-mounted, screwdriver-type adjustment receptacles 110 for adjustment of "run-time"(from 10 seconds to 5 minutes) and "wait-time" (1 to 10 minutes). Indicator LEDs (light-emitting diodes) are provided to indicate activation of "run-time"and activation of "wait-time", for set up pro-

cedures.

[0044] The device 1 and how it is connected is shown in Figure 2. The control module 10 is connected to a power source such as an outlet plug. In the preferred embodiment, it also provides power to the flow switch 40, solenoid valve 30 and the pump 50. The water supply line 80 provides water to the water heater 60 and to the cold outlets such as faucets in the plumbing fixtures 300 through the cold water line 210. Before reaching the water heater 60 the water supply line 80 runs through the T-fitting 70 into the flow switch 40 to the pump 50 and then into the water heater 60. The water heater 60 supplies heated water through the hot water line 250 to the plumbing fixtures 300. The return line 220 is connected to the hot water line 250 at the furthest fixture 300 from the water heater 60, through the manifold 20 with the check valve 25 and/or the solenoid valve 30 into the T-fitting 70 where it connects to the water supply line 80. This allows the hot water line 250 to be purged of cooled water and refilled with hot water, with no waste.

[0045] *Operation*

[0046] Figure 3 shows the flowchart for the control module. The user turns the water on. If it"s hot, they use it; if it"s not

hot, they turn the water off and wait a minute. Turning the water on is the control module"s 10 cue that hot water is requested. The control module 10, through the flow switch, detects hot-water flow. When hot water is requested from any hot water faucet 300 or appliance (by water flow), the high-performance pump 50 begins to operate and the solenoid valve 30 opens simultaneously. Water circulates at high velocity, quickly purging cooled water from the hot-water system. Circulation continues for the adjusted period of "run-time" (approximately one minute in the test water system), at which time the pump 50 stops, and approximately 1.5 seconds later; the solenoid valve 30 closes, discontinuing the flow of water from the hot-water system into the cold-water system. The delay in solenoid 30 operation prevents "water-hammer effect." When the control module 10 senses there is no flow of hot water, it begins timing the adjusted "wait-time." The control module 10 will not begin circulation until the "wait-time"has expired. If flow is detected before expiration of the "wait-time,"the timer resets and waits for the next "no-flow" condition before timing begins again. The system design assumes that cool water is purged from the hot-water system if flow was detected

inside the "wait-time." The "wait-time" prevents hot water from circulating through the cold-water system. "Wait-time"must correspond with the length of time it takes water to cool to an unacceptably cool temperature in the hot-water system. "Wait-time" will vary greatly depending upon each water system and user preferences.

[0047] In setting up the device 1 at the specific fixture where the manifold valve 20 is to be installed, the user needs to use a stop-watch or other suitable timing device and time how long it takes for hot water to "begin" to arrive, before it is actually hot. Divide that time period by two (2). This is the beginning "run-time." Next, the hot water is turned on at the same fixture and is left on until the water is hot (as hot as it will get). Then the water is turned off and the user waits for two (2) minutes. The water temperature is then tested to see if it has cooled down to an undesirably cool temperature. The water flows for a few moments to allow the cooler water to purge the hotter water. If the water is too hot, the user continues to run the water until it is as hot as it will get. Again, the water is turned off for a wait of three (3) minutes. The water is re-tested again, as instructed above. If the temperature is cooled sufficiently at three (3) minutes, this is the device"s "wait-

time." If not, the test is continued until a desired "wait-time"is established. The "run-time"and the "wait-time" are recorded for reference.

[0048] An LED labeled "Run Time"or "RT"indicates the duration of the pump "run-time." In the preferred embodiment the default is approximately 45 seconds. Another LED labeled "Wait Time"or "WT"indicates the duration of the "wait-time." In the preferred embodiment the default is approximately 4 minutes. The wait-time is adjusted by turning the adjustment receptacles 110 clock-wise to increase the time and counter-clock-wise to decrease the "run-time"and the "wait-time" to correspond with the times recorded. A "run-time"that is too long, or a "wait-time"that is too short could result in delivering completely hot water to all cold-water outlets.

[0049] To act as a fail-safe, in the preferred embodiment, during a "no-hot water condition,"the maximum amount of time the device 1 will operate the high-performance pump 60 is approximately one minute, or the "run-time." The device 1 does not rely on a specific temperature condition for any action. In the event of a significant leak in the hot-water system, the system will still only operate for approximately one minute, or the "run-time."

[0050] *Alternative Embodiments*

[0051] As shown in Figure 4, a retrofit installation is similar to a standard device installation as far as the pump 50, flow switch 40, and control module 10 are concerned. As shown in Figure 5, because there is no dedicated hot-water return line, the manifold 20 is fitted with two additional T-fittings 75, one on each end for in-line installation between the water supply lines (cold 210 and hot 250), and faucets of a suitable plumbing fixture 300, having both hot and cold water, and located the farthest from the water heater 60. In a retrofit installation, the cold-water supply line 220 is used for returning purged water to the water heater 60. The T-fittings 75 have appropriate fittings for installation using two 3/8" standard plumbing flexible hoses 100 for each line, hot and cold water. The solenoid valve 40 is connected electrically in similar fashion as in the non-retro installation with terminals at module 10, except that the wire is longer to span the greater distance between the control module 10 and the manifold 20.

[0052] Improper set-up and adjustment of the "run-time"and "wait-time"control module settings will result in wasted resources (energy or water). In a retro fit, it is preferable

to use the farthest plumbing fixture, preferably a tub faucet, for initial "run-time." Divide that time by two (2) for beginning "run-time." Use the same "wait-time" procedure as described above from the same faucet to determine "wait-time." To optimize: Over time, reduce the "run-time"a small amount and test each time until water at the farthest fixture does not reach "fully hot," then return the "run-time"setting to the next previous setting. Similarly, increase the "wait-time"until the water in the hot-water system has cooled to an undesirable temperature, and then return the "wait-time" setting to the next previous setting.

[0053] *Advantages*

[0054] The previously described version of the present invention has many advantages. The device 1 is easily installed by most do-it-yourselfers. No licensed electrician is required because 110-volt service is usually available near a water heater, low-voltage electrical wiring for the flow switch 40 and solenoid switch 30 do not require a licensed electrician for installation. There is no need to interrupt a complete water system. Installation of the pump and flow switch can be done by turning localized water off with the water heater cut-off valve (during which time cold water

will still be available through the rest of the system), and most plumbing fixtures have separate cut-off valves for both the hot and cold water lines, for installation of the retrofit manifold, which will only interrupt water at the installation-fixture. The device 1 auto-starts circulation for appliances, such as washing machines and dishwashers with multiple cycles or that start unattended, with remote timers. The device 1 does not compete for space. There"s always enough room over and next to the water heater for component installation, and the retrofit valve fits above the water supply valves, in an area that is not utilized. The adjustment of pump "run-time" is superior to temperature sensing, because temperature-sensing systems typically delay on providing a signal. Timing the length of flow time ("run time") and the length of cool time ("wait time") is superior to temperature sensing, because it provides quick resets and allows consumers to customize their preference. Mounting the high-performance pump and flow switch on the cold-water side of the water heater extends the life of the pump and switch, because they do not experience extreme temperature changes the water is cold as it enters the water heater.

[0055] Although the present invention has been described in

considerable detail with reference to certain preferred versions thereof, other versions are possible. Therefore, the point and scope of the appended claims should not be limited to the description of the preferred versions contained herein.

[0056] As to a further discussion of the manner of usage and operation of the present invention, the same should be apparent from the above description. Accordingly, no further discussion relating to the manner of usage and operation will be provided.

[0057] With respect to the above description, it is to be realized that the optimum dimensional relationships for the parts of the invention, to include variations in size, materials, shape, form, function and manner of operation, assembly and use, are deemed readily apparent and obvious to one skilled in the art, and all equivalent relationships to those illustrated in the drawings and described in the specification are intended to be encompassed by the present invention.

[0058] Therefore, the foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to

the exact construction and operation shown and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

[0059]